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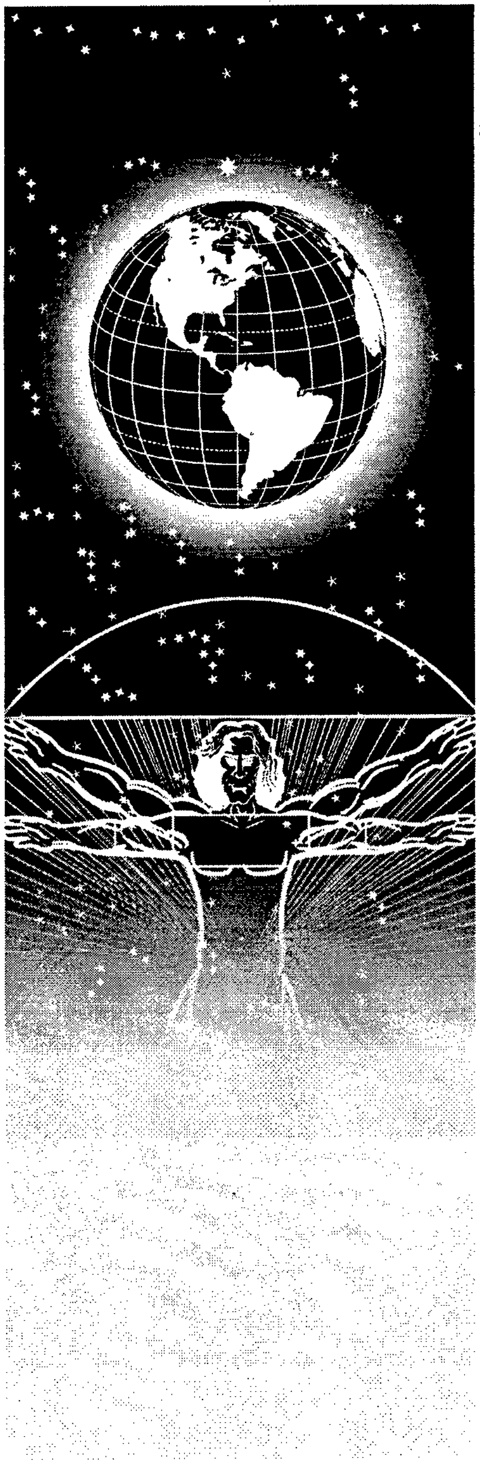

UNITED STATES AIR FORCE
ARMSTRONG LABORATORY

Shiftwork: Basic Concern for Commanders, Supervisors and Flight Surgeons

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October 1996

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	October 1996	Intermediate December 1995 - January 1996

4. TITLE AND SUBTITLE

Shiftwork: Basic Concern for Commanders, Supervisors and Flight Surgeons

5. FUNDING NUMBERS

PE-62202F
PR-7184
TA-59
WU-01

6. AUTHOR(S)

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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

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8. PERFORMING ORGANIZATION REPORT NUMBER

AL/CF-TR-1996-0073

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The purpose of this report is to provide commanders, supervisors and flight surgeons with a source for the quick study of basic shiftwork related issues. It presents a brief overview of circadian physiology, shift scheduling concepts, social issues and some strategies for making shiftwork more tolerable. It is not intended to be a detailed scientific literature review; numerous references are provided for that purpose. The choice of shiftwork schedules can have a large impact on the performance, safety, fatigue, family lives and social lives of shiftworking personnel. Rapidly rotating and permanent shift schedules appear to be less damaging to health than other shift schedules. Performance in the early morning hours appears to be sacrificed on rapidly rotating schedules and may be best preserved on permanent schedules. Fatigue can be expected to be greatest on the night-shift of backward rapid rotation schedules if quick turns are used, and on day-shifts if there is an early shift changeover time. There is no single, best coping strategy, but good sleep is essential. The serious problems associated with shiftwork are best addressed using multiple, simultaneous, interventions. This is best accomplished in a concerted effort with the active involvement of management, the shiftworkers, and their families.

14. SUBJECT TERMS

circadian rhythms	safety
fatigue	shiftwork
performance	sleep

15. NUMBER OF PAGES 30

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

NSN 7540-01-280-5500

Standard Form 298 (Rev 2-89) Prescribed by ANSI Std Z-39-18
298-102 COMPUTER GENERATED

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INTRODUCTION

The use of 24 hour operations is continuing to increase in both military and civilian organizations. With 24 hour operations comes the need for shiftwork. At a typical military base, shiftworkers can be found in air traffic control, maintenance, police/security, command post, communications, medical facilities, fire departments and other support services. As the use of shiftworkers increases, so does the need for commanders, supervisors and flight surgeons to understand the potential performance, safety, health and social implications of various types of shiftwork schedules. The purpose of this report is to provide commanders, supervisors and flight surgeons with a source for the quick study of basic shiftwork related issues. This report presents a brief overview of circadian physiology, shift scheduling concepts, social issues and some strategies for making shiftwork more tolerable. This report is not intended to provide a detailed review of the relevant scientific literature; numerous references are provided for that purpose.

DISCUSSION

BASICS OF CIRCADIAN PHYSIOLOGY:

Most of our physiologic functions operate in cycles. A woman's menstrual cycle lasts about a month. A newborn infant usually has a sleep/wake/eat cycle of about four hours. Most of our physiologic cycles last about a day; these are called circadian (Latin: "about a day") rhythms. We usually fall asleep, wake up, get hungry, etc. at about the same time every day. Most of our hormones follow a regular daily schedule, and most of our other physiologic processes do the same. Body temperature provides a good example; it follows a very regular, approximately sinusoidal, daily pattern with the peak body temperature occurring in the late afternoon and the lowest body temperature occurring at about 0400.[56] Many things can affect body temperature (e.g., activity, various hormones, ambient temperature) and mask this underlying pattern. If all these various influences are factored out the unmasked sinusoidal circadian rhythm for body temperature remains.[55,64]

The circadian rhythms of our physiologic functions are coordinated by a neural timing system. This "body clock", often referred to as the endogenous pacemaker, is located in the part of the brain called the hypothalamus.[56] It tends to run slightly longer than 24 hours in most people so it must be reset each day.[80] The daylight/darkness cycle from the environment appears to be the most powerful mechanism for resetting the pacemaker.[25] Habitual activities such as shaving, showering, and breakfast also have this ability but are considerably weaker than the light/dark cycle. Something which is able to reset the body clock is referred to as a zeitgeber (German: "time giver"). The scientific study of the interaction of the endogenous pacemaker with the circadian rhythms and zeitgebers is part of the field of chronobiology.

Most people are familiar with jet lag. The concept of shift lag is very similar. Jet lag occurs when a person has suddenly been transported a long distance east or west, and the zeitgebers in the new external environment stimulate that person's endogenous pacemaker and circadian rhythms to adjust to the new time zone. This is a considerable undertaking for the body, and it

occurs relatively slowly - about one day for each time zone which has been crossed.[21] If a person has flown from Chicago to Paris they have crossed 7 time zones; it will take approximately one week for most of the circadian rhythms to fully adjust. In the meantime, the circadian rhythms are no longer synchronized with the external environment, the person's new work/rest cycle, or with themselves. This is called internal dissociation, or desynchronosis. This often makes the person lose their appetite, feel run down, have changed bowel habits, experience problems sleeping and exhibit reduced performance.[75] Repeated internal dissociation over a long period of time may also lead to chronic health problems.[72]

Internal dissociation may also occur when shiftworkers change shifts. Similar to jet lag, the clinical expression of this is referred to as shift lag. An eight hour shift rotation is similar to crossing eight time zones while traveling. It takes at least a week to adapt to an eight hour shift rotation. A rotation from a day to a swing-shift may take less than a week because shiftworkers tend to have similar awake/rest cycles and times for the social zeitgebers (i.e., bed times and waking times) on these two shifts. Shift lag is usually worst when rotating to the night-shift because shiftworkers must change their work/rest cycles and social zeitgebers drastically. Perhaps more important is that the zeitgebers from the external environment are acting to keep the circadian rhythms in a daytime (diurnal) orientation; the new work/rest cycle and social zeitgebers are in a nighttime (nocturnal) orientation. Thus, there is a mismatch between the powerful light/dark cycle zeitgeber and the new, nocturnal, work/rest cycle. This may prevent full adaptation from ever occurring. When night-shiftworkers awaken in the evening before work their habit cues get them synchronized and ready for their shift. Exposure to sunlight on the drive home, or other exposure to bright light during the day, works to undermine the nocturnal orientation and attempts to resynchronize the endogenous pacemaker to a more diurnal orientation. After three weeks or more of non-rotating night-shiftwork most of their circadian rhythms may become synchronized to the occupationally induced nocturnal orientation.[3,45] However, some circadian rhythms will never fully adapt to a nocturnal setting.

PERFORMANCE AND SAFETY EFFECTS:

It is difficult to maintain maximal shiftworker performance during all phases of a shiftwork rotation due to two main factors: circadian rhythms and sleep debt.

Most components of human performance appear to follow a circadian rhythm [40,59,61,66] very similar to that for body temperature. Performance is usually best in the late afternoon and worst in the very early morning for a typical diurnally oriented person.[8,14,34,47] Several high profile disasters have been associated with the early morning drop in performance. These include the Chernobyl and Three-Mile Island nuclear reactor incidents,[26] the Bhopal chemical release,[30] the grounding of the Exxon Valdez,[75] and the Space Shuttle Challenger accident.[57] Major disasters are only one end of the spectrum; motor vehicle accidents on the drive home or injuries at work are more frequent. In the case of the lower profile incidents, the root cause is often unrecognized or ignored.[58]

Diurnally oriented shiftworkers will have impaired performance if they must work in the early morning hours, even if they are well rested. This impairment will be compounded if the shiftworkers have a sleep debt and are fatigued.[3] In the absence of a significant sleep debt, much of this impairment will disappear if their endogenous pacemakers and circadian performance rhythms are given an opportunity to resynchronize to a nocturnal orientation.

Performance rhythms may be somewhat job specific. Most psychomotor performance peaks in the late afternoon (1600 - 1800) and dips in the early morning (0300 - 0500) but some other components of performance may have very different rhythms.[62] For most jobs, however, performance will be best during the day if the rhythms are diurnally oriented and during the night if the rhythms are nocturnally oriented. This may vary slightly depending on the mix of performance components needed for a specific job.

Many shiftworkers carry a significant sleep debt.[16,50] Numerous studies have consistently shown that performance declines in response to sleep deprivation.[23,27,49,69] Moderate performance decrements and increased sleepiness are noted after restriction to 5 hours sleep or less.[12,22] Impairment of performance and levels of alertness occurs with as little as 2 hours of sleep loss relative to an individual's "normal" night's sleep.[11] Performance deficits due to sleep problems are additive to circadian effects and are likely to be of greater magnitude than circadian effects in many shiftwork operations.

When reviewing the relevant scientific literature regarding the performance effects of a shift schedule you may be interested in implementing, it is important that you keep the provided information in the proper perspective. In a laboratory it is relatively easy to demonstrate statistically significant performance decrements associated with time of day for the different shiftwork schedules. These decrements are important and should be carefully assessed when choosing among various shiftwork schedules. It is also important, however, to keep in mind that there may be a difference between a performance decrement which is *statistically* significant and one that is *practically* significant. A difference which may have profound safety implications may still be too small to register statistically. Similarly, a statistically significant difference may have no practical significance. Error rates and safety rates can be very useful in assessing the practical significance of performance rhythms. However, keep in mind the potentially confounding effects of differences in manning, workload, supervision, training, etc. which normally occur between different shifts.

SHIFT SCHEDULE CONSIDERATIONS:

There are a vast number of possible shift schedules from which to choose. Many have been quite creatively designed. Great care must be taken when selecting or designing a shiftwork schedule in order to sustain performance, maintain safety, minimize adverse health consequences, and minimize social disruption and adverse effects on morale.

There are five key questions which must be answered as you begin to design a schedule: 1) does the schedule need to cover 24 hours (continuous) or some fraction of the full 24 hours (discontinuous); 2) what will be the duration of each work shift; 3) how fast will the shifts rotate; 4) what will the direction of rotation be; and 5) at what time of day will the shifts change over?

Continuous versus discontinuous. This is a very important question. It is also usually the simplest. Does your mission require continuous 24 hour operations? Continuous operations are certainly on the rise, but it would eliminate a number of difficulties if you can avoid them. Discontinuous schedules which eliminate early morning coverage are likely to minimize internal dissociation and its problems.

Shift duration. How long will your people be working each day? Will all shifts be the same length? Shifts usually vary in duration from 4 to 12 hours, but shorter and longer shifts may be found as well. The usual decision is between an 8 and a 12 hour shift. It is somewhat intuitive that a person will be more tired at the end of 12 hours than at the end of 8 hours. The 12 hour shift would be expected to increase fatigue most on rotating night-shifts because the extra 4 hours occurs in the early morning hours during the usual circadian performance trough. There have been numerous studies comparing 8 and 12 hour shifts. Some indicate that there is an increase in fatigue and/or a significant decrease in performance on 12 hour shifts,[10,13,18,66,74] while others have found no significant differences in fatigue or performance.[24,33,54,82] The significance of the conclusions of most of the studies in both groups is difficult to assess because often both the shift rotation pattern <u>and</u> the length of the shift have been changed. Often, an 8 hour weekly rotation has been replaced with a 12 hour rapid rotation. Therefore, it is difficult to determine if observed differences are due to the shift duration or to the speed of rotation. On balance, 12 hour shifts can reasonably be expected to be more fatiguing than 8 hour shifts and performance may suffer as well.

Although 12 hour shifts can be expected to contribute to fatigue, they are often tremendously popular with personnel. Personnel often do not mind putting up with the fatigue associated with the extended duty hours because they get more days off. On average, they work a little more than three days each week (in a standard 40 hour workweek)(see figure 1 and table 1). They can spend the rest of the time at school, with their family or enjoying recreational activities.

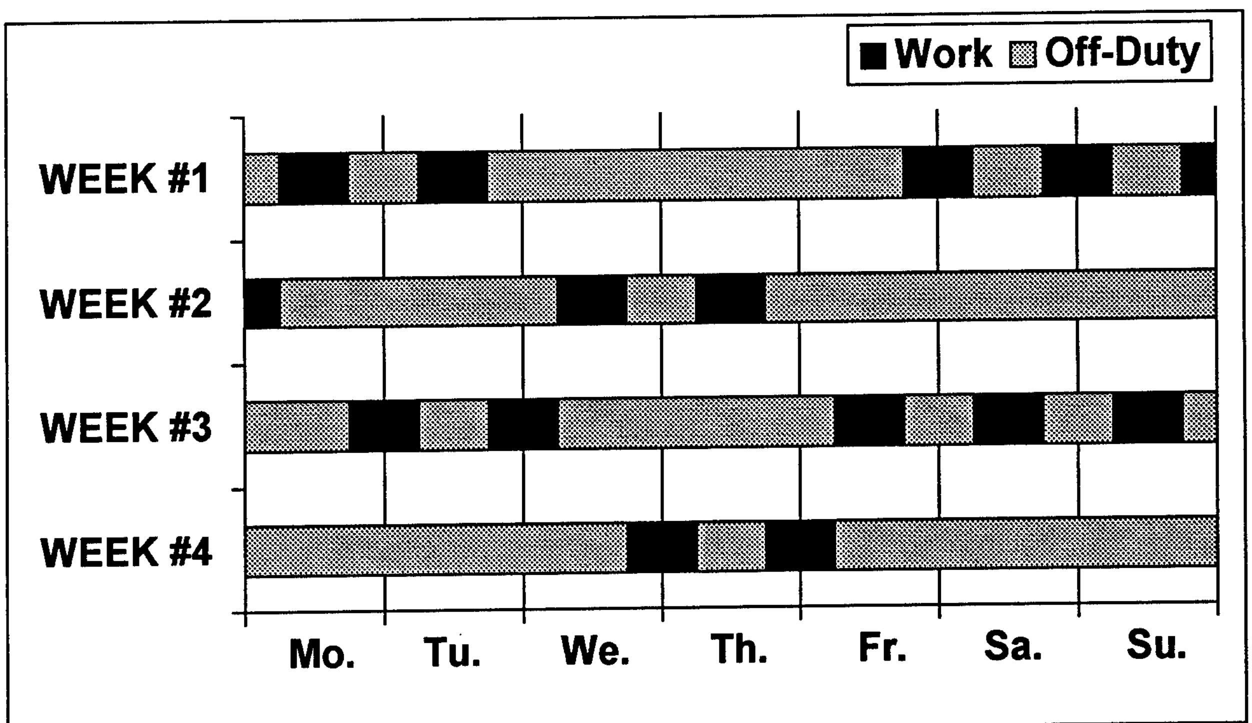

Figure 1. Example of a Rapidly Rotating 12 Hour Shift Schedule - the "EOWEO". This schedule is often very popular because it provides long weekends every other week. It is thus referred to as an "EOWEO" ("Every Other Weekend Off"). It must be used with caution, however, because of the potential for increased fatigue due to the relatively long shift length and the short recovery time between consecutive shifts within each phase

	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su
1	D	D	O	O	N	N	N	O	O	D	D	O	O	O
2	N	N	O	O	D	D	D	O	O	N	N	O	O	O
3	O	O	D	D	O	O	O	N	N	O	O	D	D	D
4	O	O	N	N	O	O	O	D	D	O	O	N	N	N

	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su
1	N	N	O	O	D	D	D	O	O	N	N	O	O	O
2	D	D	O	O	N	N	N	O	O	D	D	O	O	O
3	O	O	N	N	O	O	O	D	D	O	O	N	N	N
4	O	O	D	D	O	O	O	N	N	O	O	D	D	D

D = Day-shift N = Night-shift O = Off-duty
1 = Team #1 2 = Team #2 3 = Team #3 4 = Team #4

Table 1. The EOWEO - All Four Teams. This is another way of describing the "EOWEO". The raster plot of Figure 1 depicted 4 weeks for Team #1. The schedule for all 4 teams is described in this table.

Shifts do not necessarily need to be of uniform length,[78] particularly if they rotate. Some operations work 10 hour day and swing-shifts to reduce the night-shift length to 4 hours. For example, the day-shift could cover 0600-1600, the swing-shift could cover 1600-0200, and the night-shift would only cover 0200-0600. This may reduce fatigue on the night-shift, but remember that any existing circadian rhythm-associated performance decrements will be unaffected. Also, the early morning shift changeover times on this type of schedule could compromise sleep. At other locations the reverse theory is applied. If work is very slow and relatively unimportant on the night-shift but intense on the day and swing-shifts you can make the night-shift 12 hours and the day and swing-shifts 6 hours.

Do you want overlap between shifts? How long? When? Some overlap between shifts is almost always necessary to allow for transition time. The extra 10 or 15 minutes required at the beginning and end of a shift are usually unimportant when designing shiftwork schedules. However, you may desire to have longer overlap periods to improve communication and coordination or to provide additional manpower at times of peak workload.

There is great room for creativity in the design of shift schedules. The schedules need not be unnecessarily tied to tradition but fatigue, sleep and safety issues must be kept in mind.

Rotation speed. The speed with which a shift schedule rotates is very important. In general, shifts can be permanent (or non-rotating), slowly rotating (usually a month or longer on each shift), weekly rotating, or rapidly rotating (only 1, 2 or 3 days on each shift). Most comparisons have been made between permanent, weekly and rapidly rotating schedules.

Rapid shift rotation schedules have been found to rotate too rapidly for circadian rhythm and endogenous pacemaker adjustment to occur.[3,30,60,67] Numerous studies over the past 30 years have verified that, for the most part, circadian rhythms maintain a daytime orientation [5,17,18,31,40,42,45] on rapid rotation shift schedules. This reduces the internal dissociation which is associated with the resynchronization of the body clock encountered in less rapid rotations.[60]

Rapidly rotating shifts are often very popular with personnel for social reasons. Most of the social world is rigidly diurnally oriented, and as the number of consecutive night-shifts increases so does the social isolation for the worker. The rapid rotation minimizes this isolation and has the added benefit of providing free time covering all periods throughout the week.[79] When considering rapid rotation schedules it is very important to keep in mind that workers on the night-shift are probably operating at the bottom of their circadian performance rhythms because this shift schedule maintains their rhythms in a diurnal orientation. It is also critically important to consider the direction of rotation for rapid rotation schedules. Refer to the discussion of rotation direction below.

Permanent and slowly rotating shift schedules aim to minimize internal dissociation and maximize night-shift performance by allowing the circadian rhythms of workers on the night-shift to become nocturnally oriented. There is considerable debate between European and American shiftwork researchers as to the degree of resynchronization in the real world of permanent night-shifts. Although it takes at least a week and often up to a month to nocturnally resynchronize circadian rhythms, this adaptation can be completely reversed after only 1 or 2 days in a diurnal orientation with adequate sunlight.[42] European researchers argue that resynchronization must begin anew each workweek because personnel are inclined to revert to a diurnal orientation on their days off.

Some workers prefer these permanent schedules because they can get into a set routine and can easily forecast their off-duty time weeks ahead of time. There can be a degree of inequity, however, with these schedules because the specific social negatives associated with each particular shift are not shared by all personnel as they are in rotating shifts. Additionally, personnel on the different shifts may develop antagonistic "we versus them" attitudes which may hinder communication, efficiency and morale.[78]

Weekly rotating schedules are the ones most often associated with perpetuating internal dissociation. These schedules rotate shifts every 7 days. Since it takes about 7 days to synchronize to an 8 hour shift change, these personnel are constantly resynchronizing. Although these schedules are among the most common due to their simplicity, it is probably best to avoid using them.

It was initially hypothesized that the reduced internal dissociation associated with rapid rotations would lead to reduced shiftwork-associated health problems. This now appears to be true when rapid rotation schedules are compared with slower rotating schedules, but may not be true when they are compared to permanent schedules. In 1986 Williamson and Sanderson reported on a group of emergency service controllers. After a change from a weekly rotation to a rapid rotation there was a significant decrease in what had been a relatively high incidence of digestive disorders, headaches, high blood-pressure, anxiety and sleep disturbances.[83] Studies of air traffic controllers in the 1960's found that their five day rotation schedule was not long enough for complete adaptation to the night-shift and caused accumulated fatigue from poor quality daytime sleep.[35,53] At the same time, other studies showed that workers who were changed from a five day rotation to a rapid rotation reported less fatigue and fewer illnesses.[38] Therefore, rapid rotation schedules seem to be preferable to weekly rotations.

When rapid rotation schedules are compared to permanent shift schedules they do not seem to provide any greater health protection. In his 1992 review of shiftwork rotation speeds, Wilkinson argued that when sickness absences are compared, permanent shift systems are on par with rapid rotation systems.[81] Indeed, most of the recent studies indicate that overall health

appears to be least damaged on permanent shift schedules.[29,81] Much remains to be learned about the comparative long-term health effects of the various shiftwork schedules. The general consensus is that if shifts must rotate, health is best protected on rapid rotation schedules. If rotation is not necessary, permanent schedules may be preferable from a health perspective. However, this is still an area of considerable debate.

Rotation direction. The direction in which a shift schedule rotates can be very important. It affects the amount of off-duty time between shift phases, and the length of each rotation cycle. It may also affect the time needed to resynchronize.

The terminology used to describe shift rotation direction can be confusing and may seem counter-intuitive. A forward or clockwise rotation of days-shifts to swing-shifts to night-shifts is considered a delaying rotation because the shift phase being rotated to begins later than the one being left (see figure 2). Take for example an 8 hour worker who will rotate from a day-shift with an 0700 start time to a swing-shift with a 1500 start time. On his next duty day, his start time will be delayed from 0700 to 1500. A backward or counterclockwise rotation is considered an advancing rotation because the shift phase being rotated to begins earlier than the one being left (see figure 3). On this type of schedule, that same worker rotating from the swing-shift to the day-shift would have his start time advanced from 1500 to 0700 on his next duty day. There usually is no rotation direction distinction made for 12 hour shifts; forward and backward rotations are usually the same for these schedules.

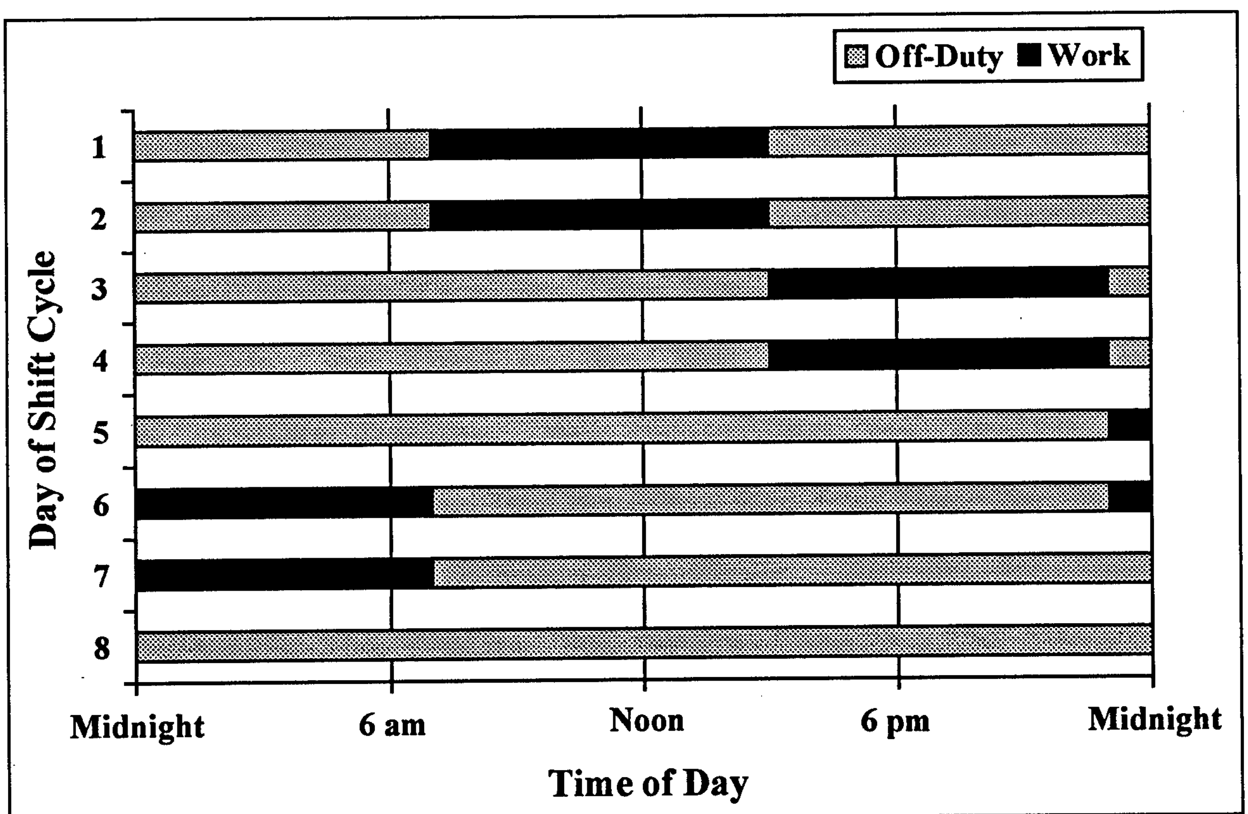

Figure 2. Example of a Forward Rotating Shift Schedule. One shift cycle from a forward rotating 2-2-2 shift schedule used by USAF air traffic controllers.[50]

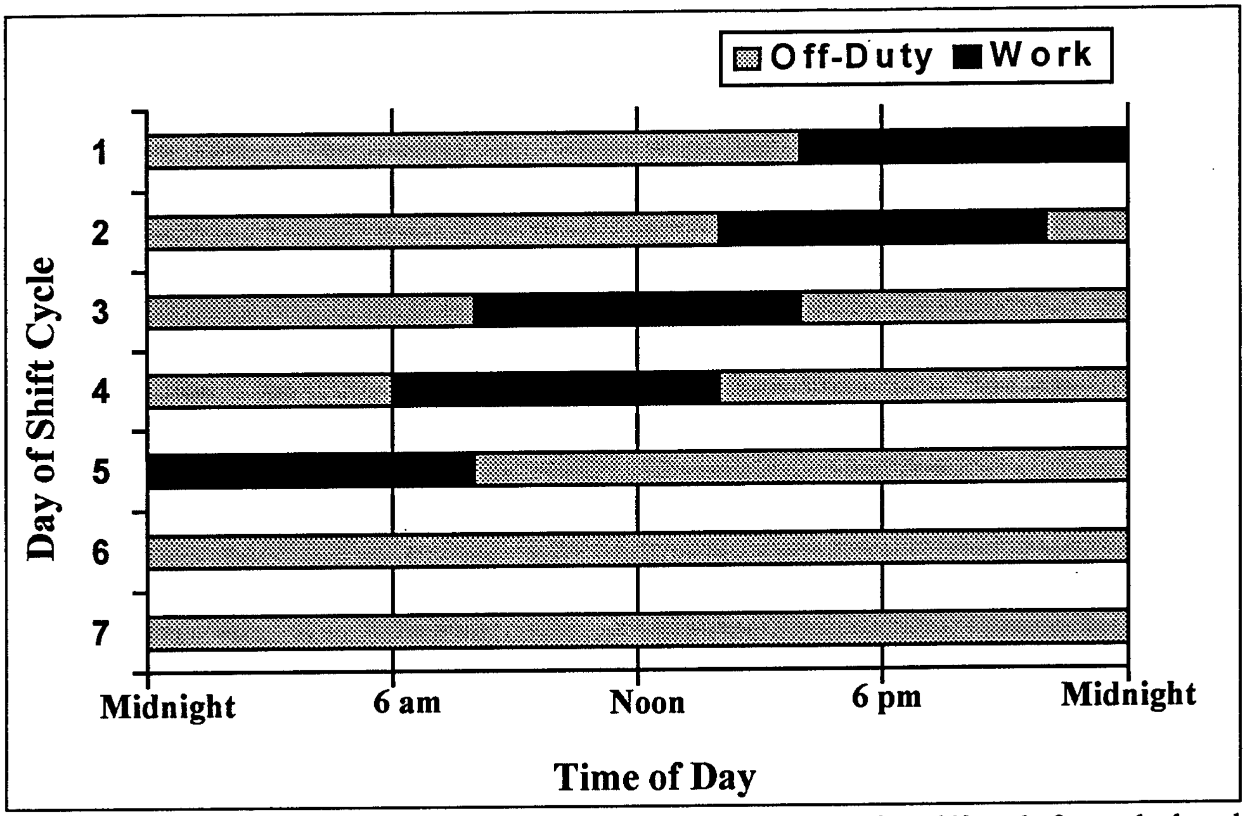

Figure 3. Example of a Backward Rotating Shift Schedule With a Slip. One shift cycle from a backward rotating 2-2-1 shift schedule used by Federal Aviation Administration air traffic controllers.[16] Note that they have incorporated a two hour "slip" into their schedule; the second shift in each phase begins two hours earlier than the previous shift of that phase.

There is usually considerably more time off between shift phases in forward rotations than in backward rotations. The difference is most significant in rapid rotation schedules. Forward rapid rotations usually tend to stretch the workweek and usually provide a full 24 hours off between shift phases. They provide ample opportunity for rest prior to a shift rotation. The "weekend" between shift cycles usually compensates by being comparatively short. Backward rapid rotations usually compress the workweek by using "quickturns" between shift phases. Quickturns on 8 hour schedules usually provide only 8 hours off between shifts during shift rotation. These schedules usually attempt to compensate by providing extraordinarily long "weekends" between shift cycles (see figure 4).

There is concern that quickturns increase fatigue on backward rapid rotations.[78] This concern is most acute for the first night-shift which follows the previous day-shift by only 8 hours on most of these schedules. During those 8 hours the shiftworker must transfer duties to their replacement, drive home, eat, perform any necessary domestic functions, sleep and return to work. Some backward rapid rotations compensate for this somewhat by providing a slip in shift start times. With a slip, the last shift in each phase ends earlier than those preceding it. This dilutes the quick turn from 8 hours to 9 or 10 hours or longer (see figure 3). Even with backward rapid rotation schedules utilizing slips, pre-night-shift sleep may be inadequate. Federal Aviation Administration air traffic controllers often use a backward rapid rotation schedule with slips. Studies have shown that they average only 2.5 to 3.75 hours sleep prior to their night-shift.[16,51,52,68,70] This acute sleep deficit can be expected to compound the circadian performance trough during the night-shift (see figure 5).

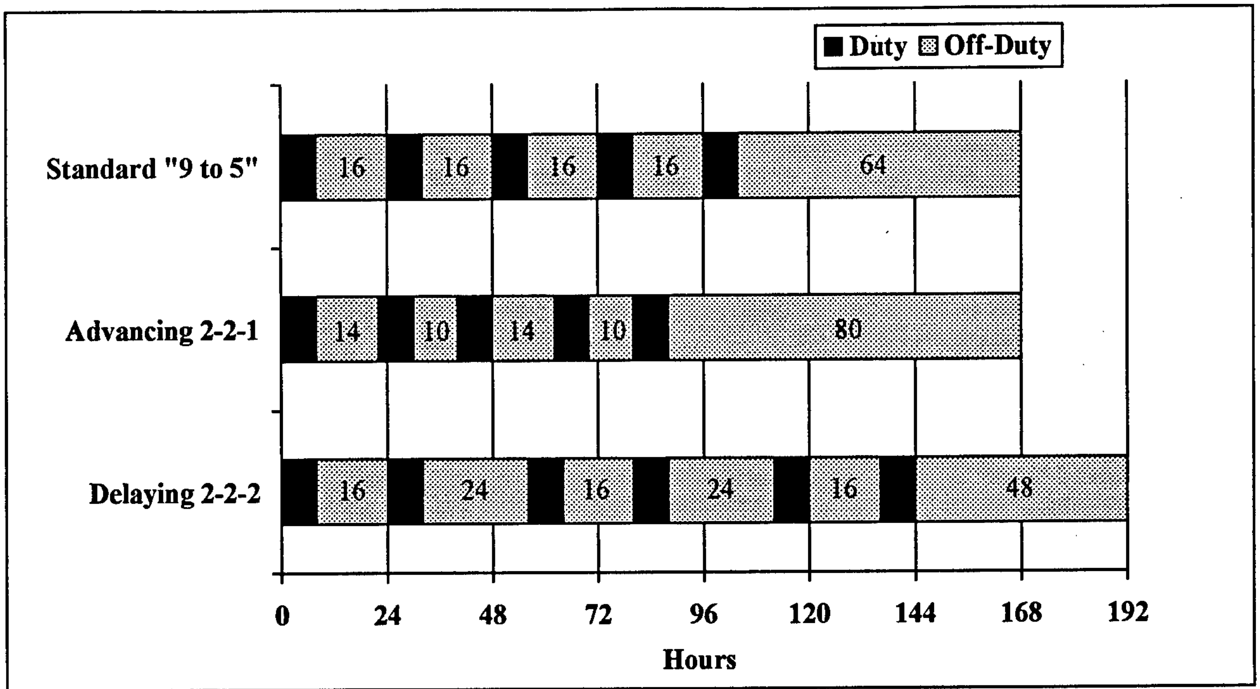

Figure 4. Comparison of Three Shift Schedules. The numerals provide the number of hours in each off-duty period. The typical duty period for each of the three schedules is eight hours. Note that in this example the delaying 2-2-2 has six duty periods [50] and the others have five per cycle. The first duty period for the "9 to 5" and the 2-2-2 is a day-shift; the 2-2-1 begins with a swing-shift.[16]

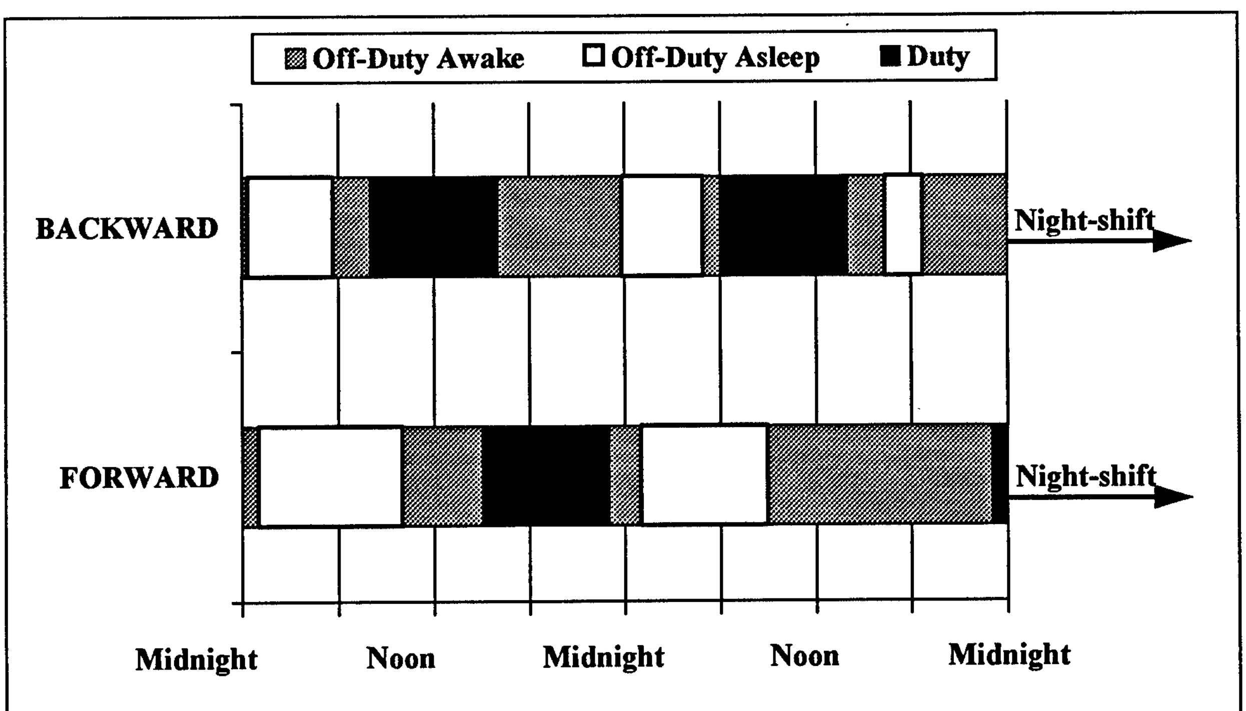

Figure 5. Comparison of Sleep Periods. A comparison of sleep periods preceding the first night-shift for air traffic controllers on a backward rotation with a two hour slip [16] and air traffic controllers on a forward rotation.[50]

Forward rotations are often felt to be easier to adapt to since they require a delay of the circadian rhythms. Since the endogenous pacemaker tends to run a bit longer than 24 hours anyway, it would seem a rotation in the forward (clockwise) direction would give the shiftworker a headstart on adaptation.[2,67,75] However, there have been very few practical studies of this. At this time, choice of shift rotation direction is therefore more prudently based on operational fatigue, safety and social considerations. Most researchers advocate forward rotations over backward rotations due to the increased fatigue associated with the quick turns in the backward schedule.[6,29,43,44,78] Personnel, however, often prefer backward schedules because of the long weekends they often provide.

Changeover time. The careful consideration of shift changeover times is often overlooked, but it is very important. The morning changeover time is most critical for fatigue and performance reasons. Morning, afternoon and evening changeover may all have important social/family/commuting implications as well.

Studies on early morning shift change-over times (0600 and earlier) have shown that although workers must get up earlier they still tend to go to bed at the same time as they do on their days off. The workers are then acutely sleep deprived as they start their day-shift.[7,28] Workers have difficulty going to bed earlier due to chronobiologic as well as social reasons.[29,43] Some researchers refer to this as the "forbidden zone" of sleep.[28] It is common for affected personnel to complain that they are actually more tired on the day-shift than on the night-shift. This problem can be rectified by making the shift change-over later.[78]

SOCIAL FACTORS:

It is important that you are aware of the profound social implications of shiftwork for your personnel. Shiftwork occupies not only the more typical off-duty periods of evenings and nights but weekends as well. As a result, shiftworkers often feel alienated from our generally diurnal, free weekend, society. Social activities cannot be planned without a work schedule on hand. Singles generally have reduced opportunities for initiating and cultivating romances because they often must work during the typical American courtship periods of evenings and weekends. Married shiftworkers' families need comparatively more self-discipline, communication and sacrifice in order to remain healthy and intact. Workers on the swing-shift may go days without being able to interact with their children.[77] Monk and Folkard refer to three spousal roles which are affected by shiftwork: care giver, social companion, sexual partner.[58] In one way or another, shiftwork will have an effect on almost every aspect of your workers' lives.[77] The effects will vary with your population of workers: young or old, single or married, parent or childless, urban or suburban or rural.

You should communicate with your workers so you can identify their shiftwork associated problems and better respond to their needs. Further assistance and information can be obtained from the sources listed at the end of this report.

MAKING IT TOLERABLE:

Once a shift schedule is in place, what can be done to maintain optimal performance and make shiftwork most tolerable for your personnel and their families? Unfortunately, there has been little scientifically reproducible research on useful strategies. Some of the following recommendations are thus based only on preliminary studies, anecdotal reports, or the common-sense in-use practices of experienced shiftworkers. Some of the recommendations pertain more to you as the commander or supervisor; others are best implemented at the discretion of the individual shiftworkers.

Individuals vary widely in their intrinsic ability to cope with shiftwork. Older, more experienced, shiftworkers have usually developed good coping strategies over the years but still usually cope less well than younger shiftworkers due to physiologic factors associated with aging. The sleep of older workers is different and their circadian rhythms have different amplitudes and phases. Coping also seems to be influenced by whether a person is more morning- or evening-oriented. Morning-oriented workers awake easily in the morning but need to go to sleep relatively early in the evening. Evening-oriented workers often have difficulty getting up in the morning but can function well late into the night. Workers who are more morning-oriented seem to generally cope less well than those who are evening-oriented. Similarly, workers who require comparatively more sleep generally have greater difficulty coping with shiftwork.[58]

Please realize that shiftwork coping is affected by factors from three main areas: circadian pacemaker, sleep, and social/domestic factors. Because of the interaction of these three factors and the intrinsic differences between individuals in coping abilities, there is no single solution to the problems of shiftwork, and no single, best, coping strategy. The problems must be addressed from several different sides simultaneously.[58] On the individual level, there are large differences in strategies for coping with rapid versus slow rotations. All shiftworkers, however, can benefit from general shiftwork and sleep hygiene education. There are other strategies which can benefit performance on the job.

Rapid versus slow rotations. In general, workers on rapid rotation schedules should attempt to stay in a diurnal orientation. They should try to get as much daylight exposure as possible without compromising their day-sleep before their night-shifts. They should avoid a heavy meal at "lunch" on the night-shift. If allowed, short naps on the night-shift can be beneficial[58] (see "naps", below).

Workers on the night-shift of slower rotations should try to maintain a nocturnal orientation. They should take only a short nap before starting each night-shift. After the night-shift they should have a light meal and then go to bed as soon as possible (earlier to bed means less adjustment of the pacemaker). Domestic chores should be saved for later. Three meals should be taken at predictable times. Night-shiftworkers should wear sunglasses when outside during daylight hours. As much as possible, they should remain on a nocturnal routine on their days-off if they will be returning to the night-shift afterward. Please note that this can be extremely difficult to do, depending on their domestic situation. They should at least try to keep their nocturnal routine meal schedule and wear dark sunglasses when outdoors. Night-shiftworkers who will be rotating to the day or swing-shift can quickly revert to a diurnal orientation by taking a nap (1-2 hr), rather than a long sleep, soon after coming home from the last night-shift and then getting a good, long, night's sleep.[58]

Education. Routine, recurring shiftwork awareness education can be useful for promoting healthy adaptive strategies. Be sure to include spouses. Family investment is very important to ensuring that your personnel are well rested and ready for work on all shifts.[58] This service can usually be provided by your local flight surgeon or occupational medicine specialist. In addition, relationships among shiftworking families should be encouraged as a means of sharing practical in-use coping strategies.

Sleep. Sleep is a major problem for shiftworkers. It is vitally important that it be protected and not be sacrificed for other demands on the shiftworker's precious off-duty time. Your affected personnel and their families should designate a fixed, regular, 7 or 8 hour block of time for the shiftworker to sleep without any interruptions. The families must be fully invested in protecting this block of time. Sleep should be in a dark, quiet, comfortable environment free of interruption. Heavy curtains should be used to make the bedroom as dark as possible. Earplugs and a thick carpet can help muffle distracting noise. Soft, constant noise - as from a fan - can be soothing and may help mask other environmental noise. Answering machines should be encouraged whenever possible to avoid interruptions from the telephone. A regular bedtime ritual should be used before each extended sleep period; this serves as a stimulus, preparing the person for sleep. Falling asleep in front of the television should be avoided. Use of sleeping pills should also be avoided. Dependency or other abuse could result because sleeping is a chronic problem area for shiftworkers. Alcohol should not be used to induce sleep; alcohol influenced sleep is less restful. Similarly, caffeinated beverages should be avoided for several hours prior to sleep.[58]

As a commander or supervisor you should also be fully invested in protecting your shiftworkers' off-duty sleep periods. Additional duties, commander's calls, etc. are usually scheduled during night-shiftworkers' off-duty sleep period. You may want to find creative ways to be more flexible when scheduling such activities. Separate dormitory facilities for shiftworkers should also be considered because these may provide more hospitable environments for day-time sleeping.

On the job, several things can be done to help maintain performance during the night-shift and other rough spots. These generally relate to the scheduling of active tasks, and the use of light, naps, temperature control, nutrition, caffeine, and exercise.

Activity. The first part of the day-shift, the end of the swing-shift, and most of the night-shift are periods most at risk for attention, alertness and performance lapses. More active or interactive tasks should be incorporated into the schedule during these times. Monotonous tasks should be reserved for the latter part of the day-shift and the first part of the swing-shift.

Light. A hormone called melatonin has been found to induce sleepiness.[75] It is naturally secreted during the late evening and early morning hours in day-oriented individuals (day and swing-shift personnel or night-shift personnel on a rapid rotation). Light intensities higher than 3000 lux, and perhaps as low as 1500 lux, have been found to suppress melatonin release [25,48] and appear to maintain alertness.[21,32] Standard room lighting is often less than 1000 lux while the light in a darkened control room is usually less than 100 lux; outside on a cloudy/rainy day it is typically 10000. Your bioenvironmental engineer should be able to assist you in determining your current light intensities. Increasing your lighting levels may be helpful.

If you wish to increase the light intensity, indirect lighting should be used. Glare and worker tolerance can be a problem so perform a test and increase illumination slowly and gradually. You may find that light intensities greater than 1500 lux are unrealistic in your specific work environment due to comfort or operational considerations. In any case, illumination should not be increased much above 3000 lux unless you are using a slowly rotating or permanent shift schedule. Controlled bright light exposure of 5000 lux and higher has been well established in animal studies and, more recently, in human studies, as a powerful resynchronizer of the body clock.[19,20,21,25,41,46,73] For rapid rotation shiftworkers (day-oriented), light greater than 5000 lux on the night-shift would tend to resynchronize their endogenous pacemaker to a nocturnal orientation. This could eventually lead to health problems. For permanent and slowly rotating night-shift workers, bright-light on the night-shift helps maintain them in a nocturnal orientation, maximizes their performance on the night-shift and assists their day-time sleep.

Naps. If manning is sufficient, employees could be encouraged to rotate naps on the night-shift.[65] Napping policies should be designed to try to minimize sleep inertia. Sleep inertia refers to a transient period immediately following awakening when an individual is confused, in a poor mood, and may be functionally incapacitated in an awake state. In order to avoid significant sleep inertia, nappers should attempt to avoid awakening during slow wave (stage 4) sleep.[63] In the absence of significant fatigue, slow wave sleep generally begins after 45 to 60 minutes.[39] Note, however, that slow wave sleep may have a much earlier onset in the presence of significant fatigue and sleep loss.[11] In such a case, naps can certainly still be beneficial, but allowances should be made to allow for the sleep inertia to resolve itself. Officially sanctioned worksite naps should therefore be limited to less than 20-30 minutes and at least 10-15 minutes should be further provided for workers to "shake off" the sleep inertia.

Worksite napping strategies are used in some international air traffic control operations [15] and in some long distance military [4] and airline flight crews. Naps may be taken in any quiet environment where the worker will not be disturbed. This may be in a break room or, as is typically the case with flight crew, at the actual duty station. Controlled studies of these napping strategies are still insufficient to make confident predictions of benefit to performance, but anecdotal reports from napping trials have been very encouraging.

Temperature, nutrition, caffeine, exercise. The work environment should be kept cool and well ventilated. Cool temperatures promote alertness.[1] Tasty, nutritious food should be encouraged and readily available on <u>all</u> shifts. All too often night-shift workers are forced to rely on candy machines and soft drinks. During long, slow periods employees should be encouraged to engage each other in stimulating conversation or games while being careful not to neglect their duties.[1] Numerous studies have found that caffeine improves night-shift performance.[9,65,71] It must be used in moderation and only early in the shift, however, to avoid affecting daytime sleep. Off-duty physical conditioning has been found to decrease subjective fatigue and increase subjective alertness on the night-shift.[36,37] Exercise during the duty shift may also be of benefit -- particularly on the night-shift. Night-time exercise has been found to suppress melatonin secretion.[76] If personnel can be allowed some time to leave the worksite near the middle of the shift and get some exercise, that could be beneficial. Alternatively, aerobic exercise equipment could be set up somewhere in the worksite.

CONCLUSION

The choice of shiftwork schedules can have a large impact on the performance, safety, fatigue, family lives and social lives of shiftworking personnel. Rapidly rotating and permanent shift schedules appear to be less damaging to health than other shift schedules. Performance in the early morning hours appears to be sacrificed on rapidly rotating schedules and may be best preserved on permanent schedules. Fatigue can be expected to be greatest on the night-shift of backward rapid rotation schedules if quickturns are used, and on day-shifts if there is an early shift changeover time. There is no single, best coping strategy but good sleep is essential. The serious problems associated with shiftwork are best addressed using multiple, simultaneous, interventions. This is best accomplished in a concerted effort with the active involvement of management, the shiftworkers, and their families.

FURTHER INFORMATION

The purpose of this report is to provide you with a succinct overview of shiftwork issues. Broader discussions of these issues can be found in several good reviews. Of particular benefit are the following volumes:

Occupational Medicine State of the Art Reviews: Shiftwork, Allene Scott editor. Philadelphia: Hanley & Belfus, 1990; 5(2).

Biological Rhythms: Implications for the Worker (OTA-BA-463), U.S. Congress, Office of Technology Assessment, 1991. Available through the U.S. Government Printing Office, (202) 783-3238.

Making Shiftwork Tolerable, by Timothy Monk and Simon Folkard, editors. Washington DC: Taylor & Francis, 1992.

Numerous scientific references are listed in the reference section of this report. You may find the following reviews of greatest interest:

Wedderburn A, ed. Social and family factors in shift design. Bull. Europ. Stud. Time 1993; 5.

Wedderburn A, ed. Guidelines for shiftworkers. Bull. Europ. Stud. Time 1991; 3.

Knauth P. The design of shift systems. Ergonomics 1993; 36:15-28.

Folkard S. Is there a 'best compromise' shift system? Ergonomics 1992; 35:1453-63. Trans. R. Soc. Lond. Biol. 1990 Apr 12;327:543-53.

Wilkinson RT. How fast should the night shift rotate? Ergonomics 1992; 35:1425-46.

The Sustained Operations Branch of the Crew Technology Division of Armstrong Laboratory at Brooks AFB in San Antonio is a good source for up-to-date information on circadian rhythms, shiftwork and jet lag issues. They can be reached at DSN 240-3464 and commercial (210) 536-3464. The Aeromedical Library at Brooks AFB may be able to provide useful advice on how to obtain some of the scientific reports which have been referenced. You can contact the library at DSN 240-3321 and commercial (210) 536-3321.

GLOSSARY

Backward: a shift rotation in the counterclockwise direction (i.e., swing-shifts to day-shifts to night-shifts). Also called an advancing rotation.

Chronobiology: the scientific study of the effect of time on living systems.[75] It includes study of the interaction of the endogenous pacemaker with the circadian rhythms and zeitgebers.

Circadian rhythms: self-sustained physiologic cycles having a period lasting approximately 24 hours.

Continuous: shift schedules which cover the full 24 hours.

Desynchronosis: see internal dissociation.

Discontinuous: shift schedules which cover less than 24 hours daily.

Diurnal: having a daytime orientation.

Forward: a shift rotation in the clockwise direction (i.e., days-shifts to swing-shifts to night-shifts). Also called a delaying rotation.

Internal dissociation: loss of synchronization of the circadian rhythms with each other, the endogenous pacemaker or the work/rest cycle. Often expresses itself as jet lag or shift lag. Also called desynchronosis.

Masking factors: external factors which make it difficult to view the activity of the underlying circadian pacemaker or circadian rhythms.

Melatonin: a hormone secreted by the pineal gland which has been found to induce sleepiness. Its secretion is suppressed by bright light.

Nocturnal: having a nighttime orientation.

Pacemaker: An internal timekeeping mechanism capable of driving or coordinating circadian rhythms.[75] Also called the body clock.

Permanent shifts: shifts which do not rotate. Also called fixed shifts.

Quickturns: the off-duty time between shift phases when that time is less than that usually received between consecutive shifts of the same phase.

Rapid rotation: only three days or less are spent on each shift before the shift is rotated.

Shift phases: the portions of the shift rotation cycle having similar duty hours. Each series of consecutive day-shifts, swing-shifts or night-shifts is a shift phase.

Sleep inertia: a transient period immediately following awakening when an individual is confused, in a poor mood, and somewhat functionally incapacitated in an awake state.

Slip: when sequential shifts of the same phase have slightly different starting and ending times.

Zeitgeber: a factor which helps to reset the endogenous pacemaker and synchronizes the circadian rhythms to the outside world.[58]

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